POLITECNICO DI MILANO

CRC

Event tree analysis

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Event Tree Analysis (ETA)

We can have (1) SYSTEM EVENT TREES or (2) PHENOMENOLOGICAL EVENT TREES.
(1) The accident sequences in the system/infrastructure are identified w.r.t. the protection and safety systems/components involved.
(2) Description of the accident phenomenological evolution that affect the system/infrastructure

- Systematic and quantitative
- Inductive

we start from the initial event and we induce what sequences can occur

AIM:

1. Identification of possible scenarios (accident sequences), developing from a given accident initiator
2. Computation of accident sequence probability

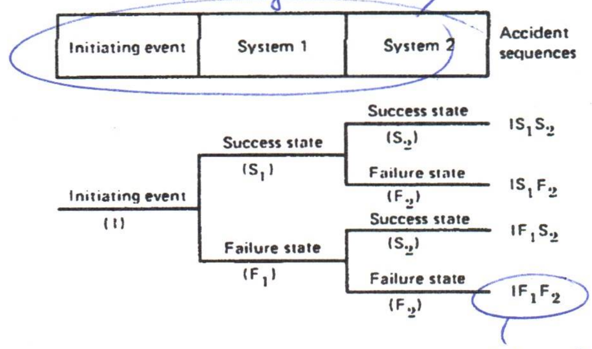
ETA: Procedure steps

1. Define accident initiator I (system failure);
2. Identify safety/protection systems (S_k) demanded by I
3. Specify failure/success states of S_k
4. Combine the states of all S_k to generate accident sequences

Event Tree

It's important to list the systems in time and logic sequence of intervention. Here for example system 1 must do something in order to system 2 kick in and start working

Headings

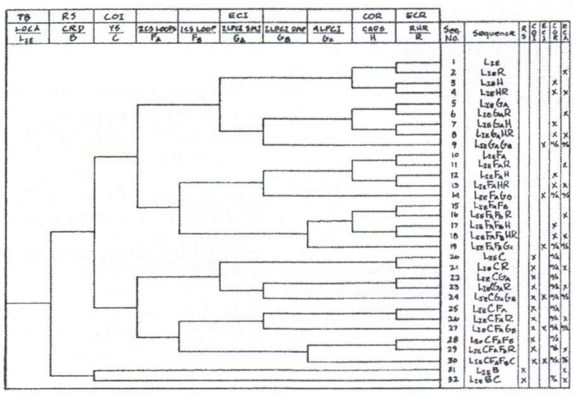


We draw lines for every possibility given an event. With this assumption of binary states of the system we delineate the system possible sequences of events.

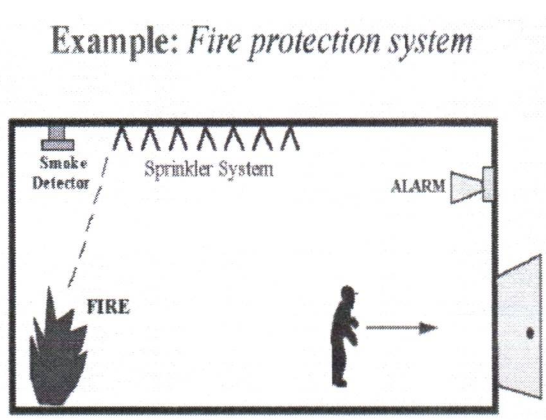
intersection of events I, F_1, F_2 (initiating event and both system fail)

In this way, if the events are independent, the probability of a sequence is the product of the probabilities along the sequence

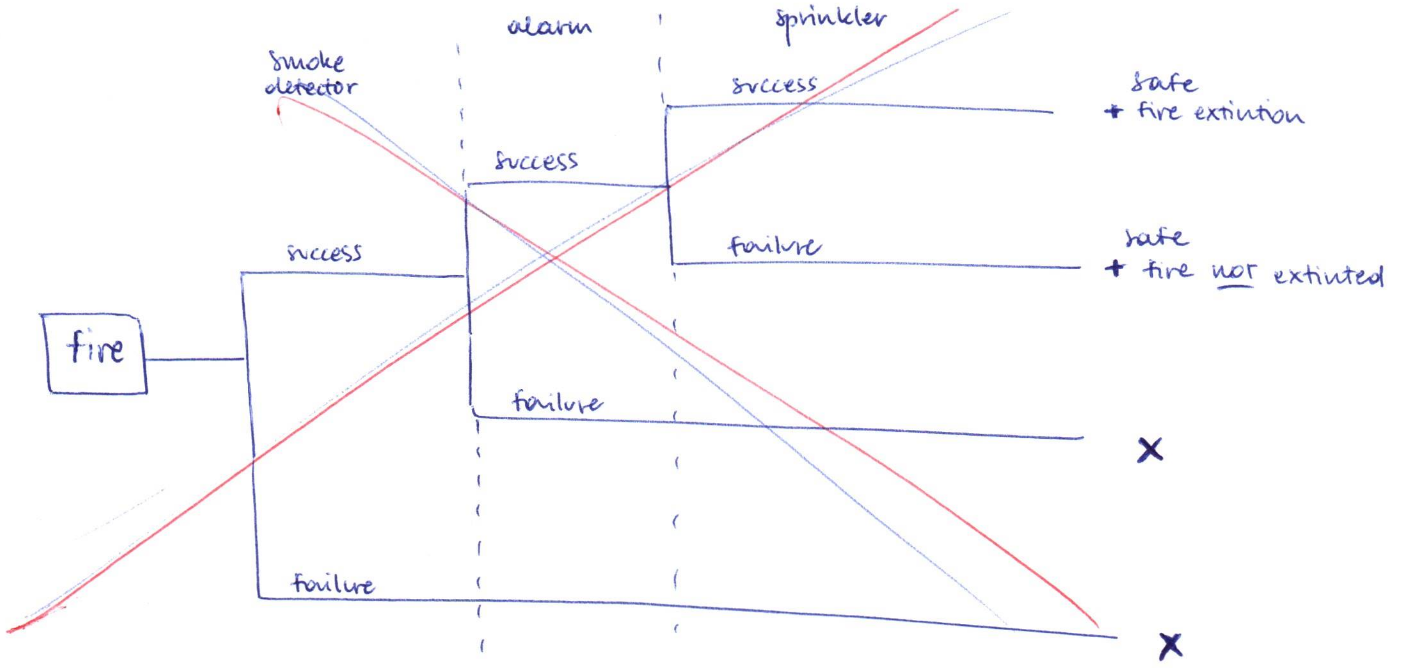
Event Tree



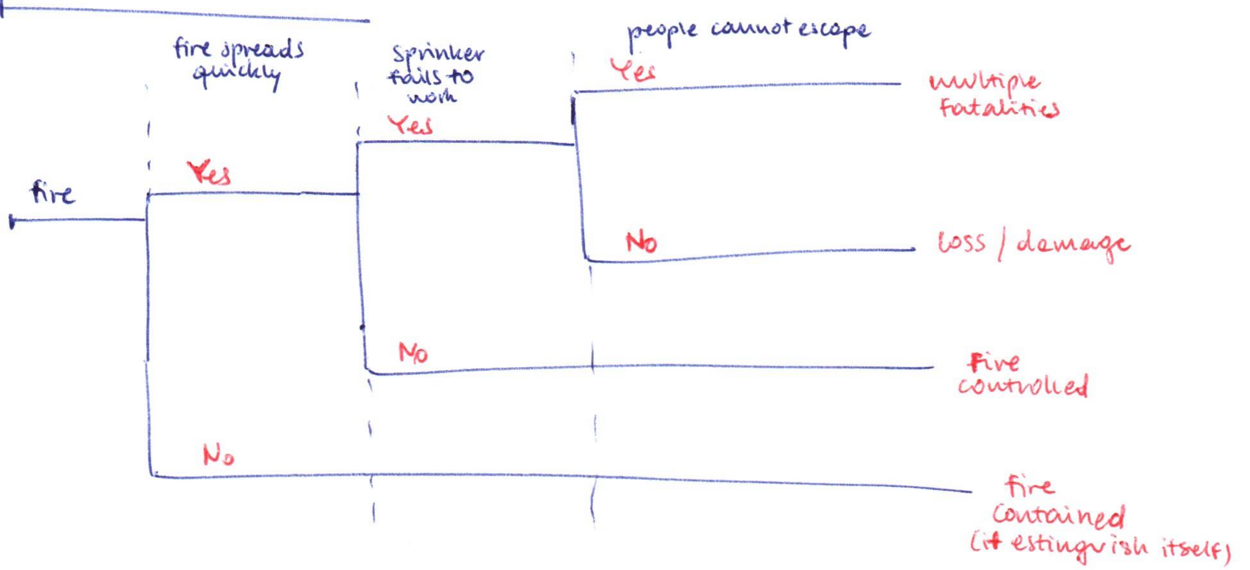
Event Tree Example 1: Fire protection system



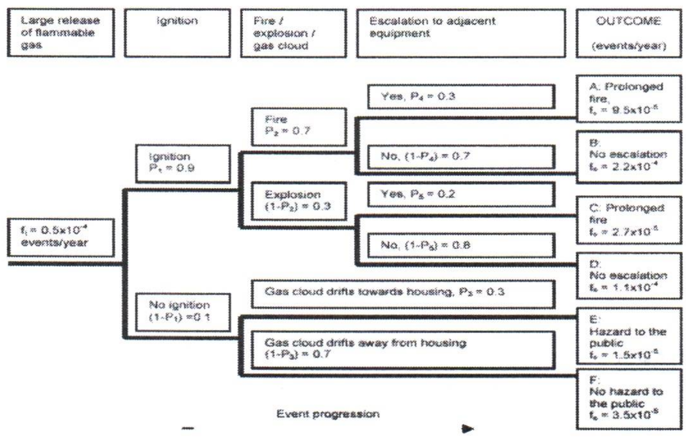
EVENT TREE - EX. 1



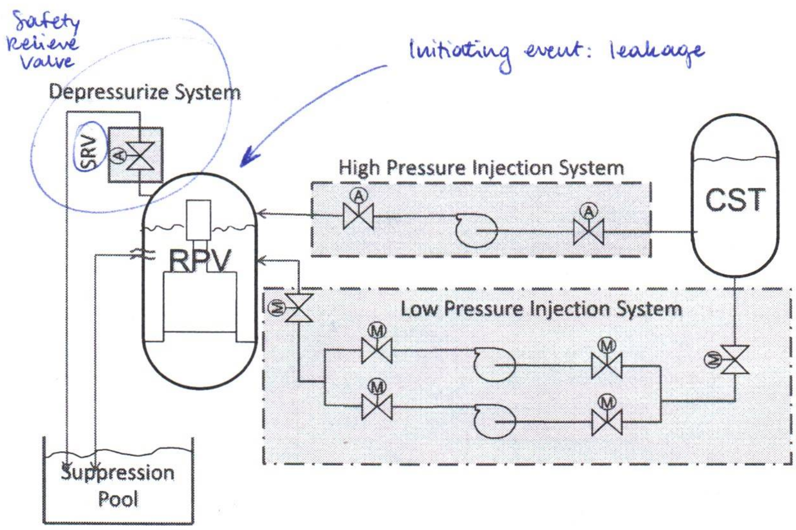
prof solution:



Event Tree Example 2: Release of flammable gas (all fenomenological)



Event Tree Example 3 Loss of coolant accident



Event Tree Example 3 (cont.)

- A small pipe crack can induce the loss of coolant of the reactor pressure vessel (RPV). The frequency of this event is 5.0E-4.
- Under the small loss of coolant accident (SLOCA) condition, the RPV water level drops due to the crack and decay heat. When it drops to a certain low level, the high pressure injection system (HPIS) starts to pump water into the core.
- In case that the HPIS works properly, the RPV can be depressurized under control and low pressure injection system (LPIS) will take care of long term heat removal to bring the core to safe status.
- If HPIS fails (at probability of 2.0E-3), the water level goes down to another setting level and trigger-starts LPIS. Then the operator has to open the safety relief valve (SRV) to relief the RPV pressure in order to keep LPIS pumping the water into the core.
- In case either the operator fails to open SRV (at probability of 5.0E-3) or LPIS fails (at probability of 5.0E-4), the core will be damaged.

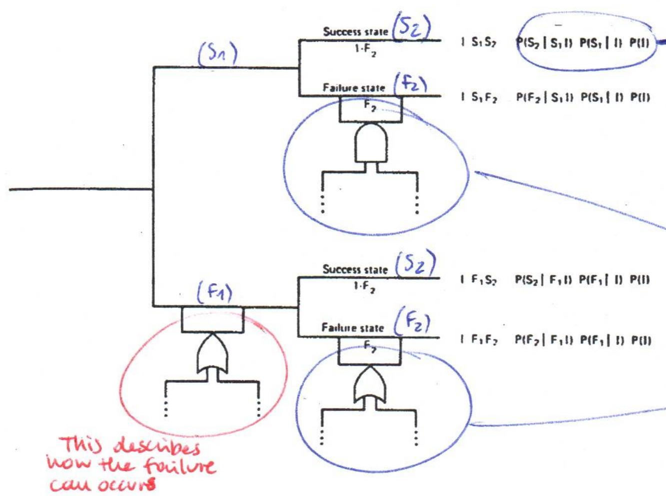
ETA: comments

1. One ET for each accident initiator
2. Time and logic of S_k interventions important for the tree structure (simplifications possible)
3. S_k states conditional on accident initiator and previous S_j's
4. Conditional probabilities of S_k states (FTA)

Remember: the probabilities are all conditional probabilities (since to get in a point a sequence of events must happen)

ETA+FTA

$\mathbb{P}(S_2|S_1,I)\cdot\mathbb{P}(S_1|I)\cdot\mathbb{P}(I)$



These are different because they're NOT describing the failure of system 2, they're describing the failure of system 2 conditioned to failure/success of system 1 !

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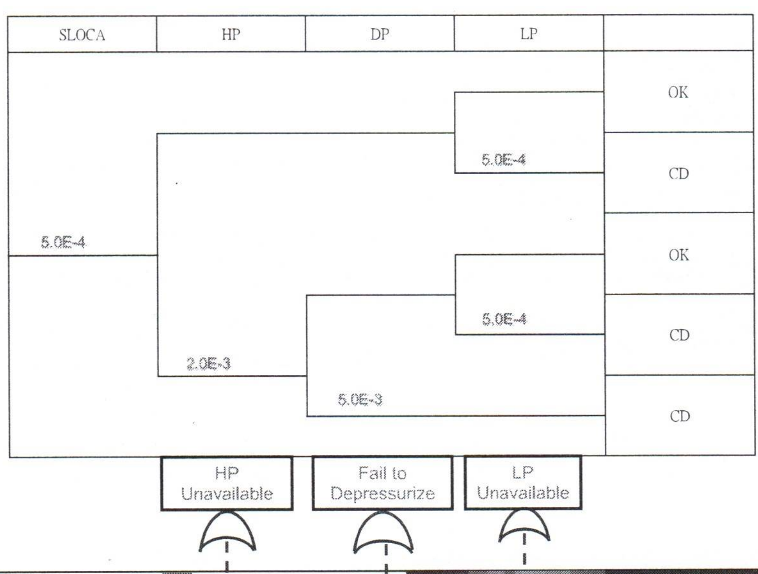
Event Tree Analysis



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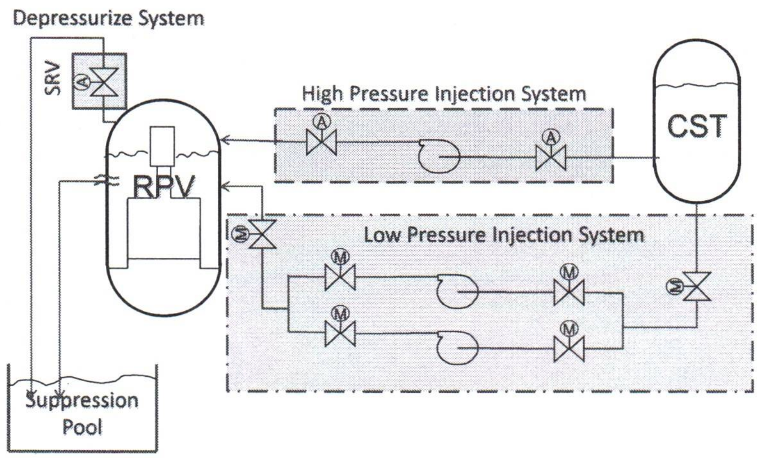
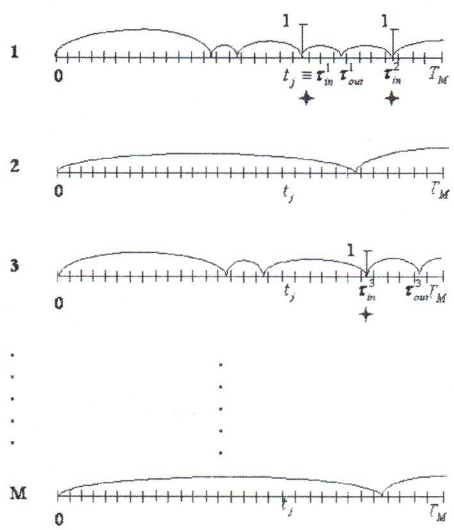
Event Tree Example 3 Loss of coolant accident



MONTE CARLO SIMULATION

- Perform many simulations (trials or histories) of the system life during its mission time
- Each trial is a random walk of the system from one stochastic configuration to another, at stochastic times.
- For each piece of walk, starting from a given system configuration k' entered at t', we need to determine when the next transition occurs and which new configuration is reached by the system.
- When the system enters in a failure configuration, we record the event realization
- Perform statistical estimates on the failure events to compute system failure probabilities

MONTE CARLO SIMULATION



1: $c^R(t_j) = c^R(t_j) + 1$

2: $c^R(t_j) = c^R(t_j)$

3: $c^R(t_j) = c^R(t_j)$

$$\boxed{G^R(t_j) = \frac{c^R(t_j)}{M}}$$